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Diseases of fishes of Drużno Lake

[Parasitofauna of the biocoenosis of Drużno Lake — part VII]

Choroby ryb jeziora Drużno

[Parazytofauna biocenozy jeziora Drużno — część VII]

There are few works in Polish literature which discuss the diseases of fishes. There are also few bodies of water in which conditions favourable to, and illustrative of, the appearance of these diseases have been examined. Lake Drużno is one of them.

We think that it is very important to point out the most essential ecological features of a given body of water when the diseases of fishes are discussed since the environment largely affects the occurrence of parasites and thereby the appearance of certain diseases.

Ecologically speaking, Lake Drużno has three characteristics largely affecting the character of fish diseases. The first is its pond-like nature. It is shallow, overgrown, has hollowings here and there where large schools of fishes may assemble. The second is that it communicates with the Vistula Lagoon and through it with the Vistula river and the Baltic, which brings about an exchange of fishes, particularly between the lake and the Lagoon. The third is that it is a reserve of birds, which affect the occurrence of certain parasites in a very high degree.

We carried out our investigation during our stay of several months between 1950 and 1953.

Esox lucius L., *Rutilus rutilus* (L.), *Scardinius erythrophthalmus* (L.), *Tinca tinca* (L.), *Carassius carassius* (L.), *Blicca björkna* (L.) and *Perca fluviatilis* L. proved to be economically the most important fish species in the lake. We examined 1,388 fishes and took into consideration all their organs as well as another 340 in quest for various parasite species, e.g. *Caryophyllaeus, Tylodelphys scheuringi,* and others. Out of total of 1,388 fishes examined only 96 were quite free from parasites.

Despite this high percentage of invasion we did not find most parasites to have pathogenous effect, but the number of parasites occurring in the fishes might have been too small to have harmful consequences. Only some of them were clearly pathogenous. The objective of our work was to find forms which could cause the appearance of disease symptoms at Lake Drużno.

The conclusion we drew from our investigation was that the youngest fry and the full-grown fishes af Lake Drużno constituted two pathologically quite different complexes unlike each other. Pathogenously most important to the fry are the parasites using fishes as their intermediate hosts, in this case, the larvae of flukes related by the development cycle to birds and settling in fish eyes and brain in particular. Invading 40 to 45% of the fry they may constitute the reason for the elimination of a considerable part of the youngest generation, a circumstance impossible to detect in the previous investigations concentrated only on the full-grown forms. Infectious diseases are of the greatest pathogenous importance for older fish generations (though the damage caused by them at the lake is not in fact considerable), and so is ergasilosis in *T. tinca* (among parasitic diseases) caused by the copepod *Ergasilus sieboldi* Nordmann, 1832.

In the present work, we have taken into consideration those infectious and parasitic diseases which may be of importance at Lake Drużno.

We discuss both types of diseases separately, and as the invasional diseases of fry are far less known we do the same with the diseases of older fishes and fry respectively, and because of difficulties in determination, the fry is treated as a separate taxonomic unit. It consisted exclusively of various species of *Cyprinidae*. No *P. fluviatilis* or *E. lucius* fry was caught.

With the view to discover the changes caused by parasites in the organs and tissues we based our investigation on observations in vivo and histological examinations. The materials were preserved for the purpose in Bouin's liquid and sublimate with vinegar acid. It was impossible to apply Zenker's liquid since it gave agglutinations with local water which were difficult to remove. Slices were stained with hemalaun-eosin and by the Mallory method.

We discovered four forms of metacercariae occurring in the brain and eyes of fish, mostly fry. We presented their description elsewhere (Kozicka, 1958). They are *Posthodiplostomulum brevicaudatum*

(Nordmann, 1832) Dubois, 1937, *Neascus scardinii* (Schulmann), *Tetracotyle* sp. 1, and *Tetracotyle* sp. 2. The first two, not observed in Poland before, occurred in the eyes and brain, of the two *Tetracotyle* species, probably not described before, *Tetracotyle* sp. 1 is specific exclusively to the brain and *Tetracotyle* sp. 2 is parasitic in the eyes only. They occur heavily at Drużno and are of clearly pathogenous importance for the condition of health of the fry. They are the most important pathogenous forms for the fishes of the lake. Also noteworthy are *Ergasilus sieboldi* Nordmann, 1832, and *Rhipidocotyle illense* (Ziegler, 1883) Vejnar, 1956 (its larval form in particular) and the metacercariae of the following flukes: *Posthodiplostomulum cuticola* (Nordmann, 1832) Dubois, 1937, *Diplostomulum clavatum* (Nordmann, 1832) Faust, 1918, and *Diplostomulum spathaceum* (Rudolphi, 1819).

Ligula alone deserves attention among tapeworms for others are not so frequent.

Of infectious diseases maculosis infectiosa in *E. lucius* and *P. fluviatilis* occur and an infectious disease of *A. brama* which we failed to identify.

We have collected some data for other Polish lakes as well and we quote them for the sake of a comparison with the relations at Lake Drużno.

Infectious diseases of fishes

The infectious diseases of fishes are a common phenomenon at Drużno. The largest damage is caused by maculosis in *E. lucius*, a disease of hitherto unknown aetiology. Although its appearance is primarily connected with the spawning-time, single specimens suffering from the disease were observed in caughts at Drużno till late autumn, and the same was stated for other lakes outside Poland by Schäperclaus (1940) and Szereszewska (after Lajman, 1949). Wounds and spots on the skin characteristic of this disease are on the whole similar to those observed in fishes from other bodies of water. They are circular or irregular in shape, dry or wet, with lesions of the epithelium and skin reaching the muscles. We observed no visible changes in the internal organs of sick fishes and this coincided with the findings of other authors.

The number of cases of maculosis amounts, according to Mr. S. Malicki, manager of the fishery at the lake, to 4—6% of the total of fishes caught yearly in 1947 to 1952 and usually stays at this

level. It is difficult to fix the number of deaths, but it is comparatively low. The disease was most intense in 1949.

Maculosis infectiosa in *P. fluviatilis*, characterized just as *E. lucius* maculosis with the presence of wounds and spots on the skin was observed in two specimens of *P. fluviatilis* out of the 73 examined in 1951, i.e. 2.7% of our material. We caught sick and very exhausted specimens of *P. fluviatilis* by hand early in August. They had large irregular wet wounds where the caudal part borders on the trunk. We failed to observe changes in the internal organs of the sick fishes with the unarmed eye, and saw no sick specimens in caughts.

As to *A. brama*, we heard as early as 1948 that there were sick specimens at Drużno. They were said to be imbibed with water as it were and thrown back into the water by fishermen when caught. But we obtained two sick specimens only in Spetember 1950. This makes ca 7% of the 26 specimens examined in that year. The examination of the sick fishes showed what follows.

Both specimens were 26 cm long. No wounds or spots were to be seen on the surface of the skin. Liquid from scale sacks jetted profusely from incisions with a lancet. The eyeballs were protruding, the anus reddened. There was a little pale pink filtrate in the body-cavity. There were no macroscopically observed changes in the internal organs except for a slight reddening of the intestine.

The damage caused by infectious diseases at Lake Drużno might be estimated, although approximately, only as regards *E. lucius* maculosis. *P fluviatilis* maculosis and the infectious disease of *A. brama* are not very frequent and remain unnoticed by fishermen and unrecorded by the management of the fishery.

Parasitic diseases of fishes of older generations

Ergasilus sieboldi v. Nordm., 1832

Ergasilosis is a disease characteristic of Drużno because of a high percentage of invasion in *T. tinca* and other fish species (Table I).

Epizootics of ergasilosis have been recorded in Western Europe since the first decade of this century and the best description of the disease and the parasite as yet is by Neuhaus (1920).

Ergasilosis has caused a very abrupt fall in the number of *T. tinca* caught at the lakes of West of Poland. As there were no documents we failed to fix the date of its first appearance at Lake Drużno and we know only that it has been long known there. The year 1946 saw

the epizootic return and the disease intensify at the lake. *T. tinca* began to die heavily and spawned poorly. The management was alarmed and obtained a permission from the Institute of Fish Diseases in Warsaw to catch the fish in all seasons of the year. Catching, particularly in winter, when there are no nauplii or young females of the parasites swimming freely, is one of the methods of suppressing ergasilosis recommended by N e u h a u s. Lake Drużno froze down to the bottom in 1947 and part of the fishes went to the Lagoon.

Table I

Ergasilus sieboldi N o r d m a n n, 1832

(Invasion of fishes at Lake Drużno in 1950 — 1951)

Host	Year	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
Esox lucius L.	1950	29	14	48	19	9	269	3 — 64
	1951	34	11	32	18	6	200	2 — 59
Rutilus	1950	27	1	4	8	0.3	8	8
rutilus (L.)	1951	23	0	0	0	0	0	0
Scardinius erythro-	1950	17	5	29	6	2	31	2 — 17
rophthalmus (L.)	1951	5	0	0	0	0	0	0
Tinca tinca (L.)	1950	16	14	87	248	217	3,473	2 — 1500
	1951	99	58	58	202	118	11,736	2 — 2400
Blicca	1950	19	0	0	0	0	0	0
björkna (L.)	1951	9	1	11	1	0.1	1	1
Abramis	1950	26	9	35	7	2	62	2 — 14
brama (L.)	1951	23	8	35	12	4	97	2 — 26
Perca fluviati-	1950	41	2	5	7	0.5	14	6 — 8
lis L.	1951	14	0	0	0	0	0	0

T. tinca escaped to the canal, where it continued to be caught as long as the frost lasted. Those winter caughts carried on systematically during that period and in later years might have helped stop the epizootic so that we could observe a certain improvement when we carried out our investigations at the lake in 1950—51. *T. tinca* spawned normally and there was a lot of fry. Although invasion in single specimens was still high and obnoxious, it was relatively rare and there was a distinct difference in the intensity of invasion between them. As regards young fishes, the proportion of invaded specimens was low and the number of parasites gradually grew with their age, while in older fishes there were unexpected bounds reaching in extreme cases the mark of 2,400 specimens in one fish (Table I).

N e u h a u s (1929) was the first to attempt to explain the differences in invasion between *T. tinca* specimens of the same age class. He thinks that a fish has a place which it likes to frequent. At such places more freely-swimming stages of parasite gather than elsewhere and fishes become most strongly invaded there. The fishes that keep far from such foci of invasion are less invaded or not at all. Sometimes whole parts of a lake may not, according to N e u h a u s, be convenient for the development of *Ergasilus* nauplius and *T. tinca* specimens caught there may be quite free from the parasite. We have been repeatedly able to confirm N e u h a u s's findings in our own observations (at Lakes Tajty and Dejgun).

Table I, showing invasion in *T. tinca* in relation to its age also indicates the differences in the height and character of invasion. The percentage of invasion in old *T. tinca* at the lake is in fact far lower than shown in the table, since the fishermen who supplied us with fishes of this age were aware of our interest in ergasilosis and tried to pick up invaded material.

The harmful effect of *Ergasilus sieboldi* on fishes has already been described. The parasite thrusts its hooks deep unto the branchial lobes, feeds on the branchial epithelium and thus causes damage to the respiratory epithelium and the tissue lying beneath it. This in turn results in haemorrhages and concrescences (Plate I, Phot. 1 & 2) hampers breathing and, in cases of high invasion, causes death.

The highest number of *Ergasilus sieboldi* we found at Drużno was in a *T. tinca* specimen 38 cm long and amounted to 2,400. The invasion must have been relatively recent since the gills were not much jagged yet (Plate I, Phot. 3).

Compared with the data of L a j m a n (1949), the numer of *Ergasilus sieboldi* found at Drużno is not the largest, as that author says that the number of parasites on the gills may amount to 5,000 to 6,000.

It is only *T. tinca* that suffers from ergasilosis at Drużno, as well as in many other bodies of water. Other species, invaded in a much lower degree, are, according to the definition of S c h ä p e r c l a u s (1954), only carriers and transporters of the parasite. The index and percentage of invasion in carriers differ from lake to lake, and most probably depend on ecological conditions, on how much the lake is overgrown, its depth, the place where the fishes stay, etc. The invasion of *T. tinca* and of the carriers at Drużno in 1950—51 is shown

Table II

*Rhipidocotyle illense** (Ziegler, 1883) Vejnar, 1956
(Invasion of full-grown fishes at Lake Drużno in 1950—51)

Host	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity ot invasion
Esox lucius L.	63	8	12.7	5.6	0.7	45	2—15
Rutilus rutilus (L.)	50	34	68.0	60.5	41.2	2050	1—300
Scardinius erythrophthalmus (L.)	22	9	40.9	42.5	17.3	382	1—100
Gobio gobio (L.)	10	5	50.0	117.0	58.3	583	1—463
Alburnus alburnus (L.)	5	3	60.0	16.3	9.8	49	14—20
Blicca björkna (L.)	28	18	64.3	124.0	80.3	2250	1—600
Abramis brama (L.)	49	41	83.7	302.0	253.0	12400	2—1500
Carassius carassius (L.)	16	5	31.2	4.8	2.6	24	2—11
Perca fluviatilis L.	58	2	3.4	1.5	0.05	3	1—2
Lucioperca lucioperca (L.)	8	1	12.5	4.0	1.8	4	4
Acerina cernua (L.)	23	2	8.7	1.5	0.2	3	1—2

* metacercariae

Table III

Rhipidocotyle illense (metacercariae)
(Invasion of fry at Lake Drużno in 1951)

Length of fish in mm	Exam.	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
0—15	35	13	37.1	4.0	1.4	52	1—20
15—20	87	32	36.7	7.8	2.8	249	1—30
20—30	140	50	35.7	8.8	3.1	440	1—89
30—40	64	46	71.8	9.5	7.1	455	1—50
40—50	25	22	88.0	10.6	9.4	235	1—38
over 50	4	3	75.0	19.6	14.7	59	1—23

in Table I. The table proves that *E. lucius* is the host to be most heavily invaded by *Ergasilus sieboldi* with *A. brama* second to it. A similar relation was observed at Lake Tajty: in 1949, *E. lucius* was invaded in 81% and the number of parasites on the fish oscillated between 2 and 68. *A. brama* was invaded only in 9.5% and the number of parasites was 1 or 2 (Kozicka, 1953).

Rhipidocotyle illense (Ziegler, 1883) Vejnar, 1956

These flukes dominate Drużno both on account of a wide range of occurrence and a high index of invasion.

Mature specimens are found in the intestine of *E. lucius* L., *L. lucioperca* (L.), *P. fluviatilis* L. and *Acerina cernua* (L.). A few thousands of specimens were sometimes found in one *E. lucius* L. Metacercariae were found in 11 species of full-grown fishes (Table II) and in fry (Table III).

Since in bucephalosis in adulf fishes clinical symptoms appear only in an extreme case of invasion, the effect of the parasite has not so far been noticed by observers. It is not mentioned in handbooks of ichthyopathology (Dogiel, 1939; Lajman, 1949; Schäperclaus, 1954). Our own observations affirm the opinion about non-pathogenic action of the mature form; the action of the larval form however, especially of metacercariae, is noteworthy.

The harmful effect of *Rhipidocotyle illense* metacercariae on the organism of fish also depends on the organ they settle in and their number. About 20 or more cysts in the eye destroy the retina and make the fish blind. But the same number in the muscles or in the skin of a full-grown fish does not seem to have any particularly harmful effect. If however there is a mass invasion the settling of the parasite even in the skin or muscles may have serious consequences, and in exceptional cases it may result in death.

Young metacercariae settle mainly in the gills, muscles and under the skin (less frequently in the nervous tissue), i. e. almost at the place of invasion; thus, since they do not make long obnoxious journeys in the body of the fish, they are less harmful in a way than e.g. *Diplostomulum spathaceum* or *Diplostomulum clavatum*.

Older, already settled, metacercariae probably act mainly by pressure. This pressure is far stronger in fry than in older fish because of the different relation of the size of the parasite to the body size of the fish. It seems that even twenty *Tetracotyle variegata* cysts on the heart of a large *Abramis brama* have less effect upon the circu-

lation than one *Rhipidocotyle* cyst on the heart of a small fish 2.5 cm long (Fig. 1).

Rhipidocotyle metacercariae settle mainly in the muscles, skin, inside the branchial arches, under the opercle, on the heart, and sometimes in the brain. It is noteworthy that metacercariae are not generally found in the fins in fry, while very many are found in the fins, especially in the caudal fin, as well as the gills in some species of older fish. *Abramis brama* and *Cyprinus carpio* are the most heavily invaded and in these, more frequently than in other species, *Rhipidocotyle illense* metacercariae settle in great numbers in the muscles, skin, neurilemma, eyes, brain and under the opercle.

Fig 1. Section through the heart (a) of the 2.5 cm long fry containing the cyst of *Rh. illense* (b)

On observation of fish directly after they were caught we noticed that the marginal rays of caudal fins in four species: *A. brama*, *B. björkna*, *R. rutilus*, and *S. erythrophthalmus*, were very often reddened, swollen and filled up with a mass resembling pus at first sight, tensile and dense. The upper parts of the rays were often stripped of the epithelium, broken and worn off. Microscopic examination showed that the pus-like mass consisted of thousands of *Rhipidocotyle illense* metacercariae. Sometimes the dorsal, pectoral and ventral fins were also invaded. Their appearance was so characteristic in heavily invaded specimens that it was possible to recognize bucephalosis at first sight.

A. brama and *B. björkna* were the most heavily invaded; the invasion in *A. brama* was sometimes so heavy that it caused not only the marginal rays to swell and wear off but also a hyperaemia of the head skin full of metacercariae. In extreme cases of invasion large ulcers may form at the basis of the dorsal fin. Such ulcers, twice observed

by us, in *A. brama* and reaching as far as the vertebral column were filled with countless *Rhipidocotyle illense* metacercariae. Cases of such heavy invasion however are exceptional at the lake. As a rule, the congestion of metacercariae in the fins seems to do no greater damage than strip and wear bare the marginal rays.

The distribution of metacercariae in the fins of invaded fishes is uneven; they generally accumulate in the marginal rays of the caudal fin (Plate II, Phot 1). There are none or hardly any metacercariae in the median rays. Their inside is filled with connective tissue only (Plate II, Phot. 2).

Anatomopathological changes in the fins depend on the number of metacercariae. Cyst crowded on a small area (Plate II, Phot. 3) exert a pressure upon the blood vessels and cause many narrowings in them (Fig. 2). This leads to disturbances in the circulation and

Fig. 2. Section through the blood vessel (a) of the fin of *A. brama*, constricted by the pressure of cysts of *Rh. illense*

stagnancies which result in anaemia and undernourishment of the segments of the invaded rays laying caudopetally in relation to the narrowings. The undernourishment causes first of all the atrophy of the epithelium and the stripping, and consequently, the breaking and wearing off of the rays themselves. The processes taking place in the tissues after the parasite enters the fish body may be divided into a few stages. First there occurs the histolysis of the tissues nearest to the metacercariae. If such newly invaded fin is cut with a lancet at that time the metacercariae flowing out of it spread on the object glass and together with them a multitude of tiny globules flow out and spread on the glass. They resemble globules of fat, a product of the decay of tissues. As a result of continued irritating action of the parasite and of the disturbances in the circulation caused by pressure a number of cellular elements begin to leave the blood and the sur-

rounding tissues, so that finally an extensive cellular infiltration forms round the metacercaria, which then transforms into granulation.

From now on the process goes on in two opposite directions in one and the same fin; here the granulation is supplanted by the connective tissue and scars form, there the parasites degenerate and infiltrations. No metacercariae flow out of the fin when it is cut with a lancet in that period; they are surrounded by the connective tissue and it is difficult to isolate them from it.

Towards winter there were fewer and fewer living mobile metacercariae found in the fins. Most of them die and only a part survive. Those single specimens which lie in the muscles, in the connective tissue or in the gills degenerate less frequently.

A high degree of invasion both by the definitive and larval forms of *Rhipidocotyle illense* has been observed by many authors. D o g i e l (1932) writes that the number of mature specimens of the parasite in the intestine of *E. lucius* L. sometimes amounts to several thousands and that other predatory fish species are less invaded than *E. lucius*. A strong invasion of *Cyprinidae* by *Bucephalidae* metacercariae was observed by D o g i e l on the mouth of the Neva River, and a similar, though lower, invasion was described by L a j m a n vast necrotic areas appear surrounded subsequently by micro-cellular (1949).

Still, mass invasion by *Rhipidocotyle illense* is not a common or frequent phenomenon. Besides strongly invaded lakes, there are some which are quite uninvaded and in most the parasites appear in very limited numbers. This is the case with Lake Tajty, where the invasion of *E. lucius* by the definitive form of the parasite varies from 12 to 30, while the number of metacercariae in *A. brama* and *B. björkna* is below 10, the average invasion being 1.5 per fish (K o z i c k a, 1950).

Lake Drużno is strongly invaded. The invasion by the mature form of *Rhipidocotyle illense* amounts to 3,000 in *E. lucius*. The metacercariae of this parasite were dicovered in eleven fish species (Table II), and *L. lucioperca, E. lucius, P. fluviatilis* and *A. cernua* proved to be both definitive and intermediate hosts. The same has been found before for some of these species by D o g i e l (1938) and D u b i n i n (1950). The degree of invasion by *Rhipidocotyle illense* metacercariae of various fish species is very uneven at Drużno. *A. brama* L., in which the number of parasites is anything up to 1,500 and the average invasion 253, and *B. björkna*, in which the maximum invasion is 600

and the average invasion 80, are the most invaded. *R. rutilus*, with a maximum number of 300 parasites and an average invasion of 41 is in the third place, while *S. erythrophthalmus*, with a maximum number of 100 parasites and an average invasion of 17, comes next. Other species (apart from *Gobio gobio*, of which only one specimen was found to be strongly invaded) are very slightly invaded. The maximum number of parasites in them varies from 1 to 20 (Table II).

It is noteworthy that the invasion of *A. brama* may be higher in extreme cases of invasion than shown in the table. The number of metacercariae which filled up the ulcers in two *A. brama* was so large that it was regarded as mass invasion apart from the parasites. The mass invasion was then taken into account as an arbitrary number of 1,500.

The degree of invasion by *Rh. illense* in the four most strongly invaded species is related to the age of fishes. *A. brama*, *B. björkna*, *R. rutilus*, and *S. erythrophthalmus* get strongly invaded from a certain category of age onwards (*A. brama* from ca 16 cm, *B. björkna* from ca 12 to 13 cm; Table III). In this connection, it may be supposed that the older generations of these species, especially of *A. brama*, stay in a different ecological niche than the younger ones, and in one where their contact with *Anodonta* and the cercariae of the parasite is longer and closer.

The high degree of invasion by *Rhipidocotyle illense* metacercariae in *Cyprinidae* at Lake Drużno is borne out by a comparison with Dubinin's findings on the delta of the Volga. The invasion of *Anodonta* and *Unio* by cercariae of *Bucephalidae* reached 96% there, while the maximum number of metacercariae per fish never surpassed the 324 mark.

Posthodiplostomulum cuticola (Nordmann, 1832) Dubois, 1937 — metacercariae

The grown-up form lives in the intestine of piscivorous birds, mainly in heron. The metacercaria of *Posthodiplostomulum cuticola*, called *Neascus cuticola* formerly, occurs chiefly in *Cyprinidae*. Its presence at Drużno was observed in five fish species: *R. rutilus*, *B. björkna*, *S. erythrophthalmus*, *A. brama*, and *A. alburnus* (Table IV).

R. rutilus proved to be the most strongly invaded. 59% of its specimens were invaded in 1950 and 39% in 1951, the intensity of invasion varying from 1 to 30. In two extreme cases, there were 650 and 250 specimens in one host respectively.

Table IV

Posthodiplostomulum cuticola (Nordmann, 1832) Dubois, 1937
(Invasion of older fish at Drużno in 1950—51)

Host	Year	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
Rutilus	1950	27	16	59.2	50.0	29.3	800	1—650
rutilus (L.)	1951	23	9	39.0	56.1	21.9	505	1—250
Scardinius erythrophthalmus (L.)	1950	17	8	47.0	8.5	4.0	68	1—17
	1951	5	1	20.0	1.0	0.2	1	1
Alburnus	1950	4	1	25.0	9.0	2.2	9	9
alburnus (L.)	1951	1	1		3.0	3.0	3	3
Blica björkna (L.)	1950	19	5	26.3	7.2	1.8	36	2—18
	1951	9	1	11.1	5.0	0.5	5	5
Abramis brama (L.)	1950	26	12	46.1	13.2	6.1	159	1—90
	1951	23	6	34.7	6.8	1.8	41	2—15

The subcutaneous connective tissue is the most typical place for *Posthodiplostomulum cuticola* metacercariae to settle in, but they are also found in the outer, surface layers of muscles. Large and easily distinguished black cysts most frequently settle under the skin in various places of the trunk and head, in the fins, on the margin of the opercle, sometimes under the parietal peritoneum, in the oral cavity, less frequently in the gills, and exceptionally in the cornea.

Except for cases of heavier invasion, this parasite is little pathogenic for full-grown fishes, while it is very obnoxious to fry. Many authors (Dogiel, 1932; Markiewicz, 1951; Schäperclaus, 1954; Lajman, 1949) quote *Posthodiplostomulum* metacercariae as causing deformities of the body, twisted vertebral column, decay of whole organs and parts of muscles, and even death of the youngest generation. Periodical *Posthodiplostomulum cuticola* invasions caused by periodical contacts with herons, reaching up to 61% with an intensity of 1 to 16 and assuming the scale of an epizootic, were observed in the delta of Volga (Dubinin, 1952).

It would be impossible to investigate the effect of the periodical contacts at Lake Drużno, where herons come to feed throughout the summer season but are relatively rare. The invasion of fish examined laboratorily in 1951 and 1952 was low (Table V). Usually one, less frequently two, and in extreme cases five and eleven parasites were

found in single specimens. The low percentage and degree of invasion in fry admits of a supposition that the damage caused by *Posthodiplostomulum cuticola* metacercariae are relatively slight at the lake. Where there are more herons, e.g. at Lake Łabędzie, situated near

Table V

Posthodiplostomulum cuticola (Nordmann, 1832) Dubois, 1937
(Invasion of fry at Lake Drużno in 1951)

Length of fish in mm	Exam.	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
0 — 15	35	—	—	—	—	—	—
15 — 20	87	3	3.5	1.0	0.04	3	1
20 — 30	140	4	2.8	2.7	0.07	11	1 — 5
30 — 40	64	5	7.8	1.5	0.3	17	1 — 11
40 — 50	25	1	4.0	2.0	0.08	2	1

a heron reserve, the invasion of fry by *P. cuticola* metacercariae was far higher and reached 20 to 25% in some schools. A far higher invasion than at Drużno was also observed there in one-year old (1+) *R. rutilus*.

Table VI

Diplostomulum clavatum (Nordmann, 1832) Faust, 1918
(Invasion of older fishes at Lake Drużno in 1950 — 51)

Host	Examined	Invaded	% of invasion	Index of invasion	Average of invasion	Total of parasites	Intensity of invasion
Esox lucius L.	63	30	48.0	17.0	8.1	511	1 — 118
Rutilus rutilus (L.)	50	39	78.0	109.5	85.5	4273	3 — 520
Scardinius erythrophthalmus (L.)	22	11	50.0	42.8	20.5	473	1 — 300
Tinca tinca (L.)	28	7	25.0	3.0	0.75	21	1 — 8
Gobio gobio (L.)	10	1	10.0	15.0	1.5	15	15
Blicca björkna (L.)	28	19	67.9	42.3	28.7	804	1 — 190
Abramis brama (L.)	49	36	73.0	21.2	15.6	764	1 — 140
Rhodeus sericeus Bloch	18	1	6.0	1.0	0.06	1	1
Carassius carassius (L.)	15	4	26.7	3.0	0.8	12	1 — 5
Perca fluviatilis (L.)	58	57	93.0	328.0	322.0	18640	17 — 800
Lucioperca lucioperca (L.)	8	7	88.0	118.0	103.0	824	1 — 356
Acerina cernua (L.)	23	23	100.0	112.0	112.0	2562	4 — 500

Diplostomulum clavatum (Nordmann, 1832) Faust, 1918

The metacercariae of this species occur in the eyes or the brain of fishes. With respect to the range of occurrence and the index of invasion these parasites occupy just as dominant a position at Drużno as *Bucephalidae*. Their presence was observed in 12 fish species (Table VI). The most typical hosts of the parasite are *P. fluviatilis* and *A. cernua*.

The mature form of the metacercaria, the fluke *Tylodelphys clavata* (Nordmann, 1832), lives in *Ardea cinerea*.

Those small (0.4 to 0.7 mm) mobile and uncysted metacercariae settle amost exclusively in the vitreous body. It was also found in the brain of 30% of *P. fluviatilis* at Drużno. The number of metacercariae in both eyes of various specimens varied from 1 to 500 and amounted

Table VIa

Diplostomulum clavatum (Nordmann, 1832) Faust, 1918
(Invasion of fry at Lake Drużno in 1951)

Length of fish in mm	Exam.	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
0 — 15	35	—	—	—	—	—	—
15 — 20	87	3	3.4	1.6	0.06	5	1 — 3
20 — 30	140	6	4.2	2.8	0.1	17	1 — 6
30 — 40	64	11	17.1	5.1	0.9	57	1 — 18
40 — 50	25	6	24.0	2,6	0.6	16	1 — 6
over 50	4	4	100.0	15.2	15.2	61	3 — 20

to 700 to 800 in extreme cases. This is not the highest degree of invasion, for according to Markiewicz (1951) anything up to a few thousands of specimens had been found in the eyes of fishes. The intensity of invasion at the delta of the Volga (Dubinin, 1952) is far smaller than at Drużno and varies from 1 to 250 per fish. The percentage of invasion of various species is very high both in the delta of the Volga and at Lake Drużno (Table VI).

It is noteworthy that the presence of even so high a number of parasites as at Drużno causes no pathological symptoms to appear in the fishes. No changes noticeable with the unarmed eye were discovered on external examination even in most strongly invaded specimens.

The pathogenic effect of these parasites on the fish has not yet been described. But as there are no disease symptoms it may be supposed that settled metacercariae lying freely in the semi-liquid substance of the vitreous body cause no major damage to the fish. It is even somewhat surprising that so considerable a number of parasites repeatedly drilling through the chorioid and the retina bring about no major reaction on the part of the eye. A possible explanation of the phenomenon it that in natural conditions, the metacercariae do not invade en masse but singly or in small groups and consequently the invasion is hardly perceptible as it were.

Table VII

Diplostomulum spathaceum (Rudolphi, 1819)

(Invasion of fry in 1951)

Length of fish in mm	Exam.	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
0 — 15	35	3	8.5	2.0	0.2	6	2
15 — 20	87	17	19.5	2.6	0.6	45	1 — 6
20 — 30	140	28	20.0	2.8	0.5	77	1 — 8
30 — 40	64	14	21.8	2.5	0.5	36	1 — 5
40 — 50	25	7	28.0	2.5	0.7	18	1 — 4
over 50	4	1	25.0	1.0	0.2	1	1

The invasion of fry at Lake Drużno proceeds roughly as it does in older fishes as described above. It starts relatively late, from a length of 2 cm on and gradually rises with age. On the other hand, in contradistinction to older fish, both the percentage and the intensity of invasion are comparatively low in fry (Table VIa), while the number of parasites varies from 1 to 6, and reaches 20 in both eyes in extreme cases of young specimens of over 5 cm long. Still, stronger and more harmful invasions are always possible.

Diplostomulum spathaceum (Rudolphi, 1819) — metacercariae

The mature form, the fluke *Diplostomulum spathaceum*, lives in the intestine of sea-gull, the metacercaria occurs in the eyes of fish. The metacercaria has just as wide a range of occurrence at Drużno as *Diplostomulum clavatum*, the index of invasion being far lower. Its presence was observed in 12 fish species (Table VIII).

In *Cyprinidae*, it settles mainly in the lense, in *P. fluviatilis* and *A. cernua* mostly in the vitreous body. Dogiel (1932) explains this phenomenon by a greater hardness of the lense in *Percidae*.

Markiewicz (1951) and Schäperclaus (1941) write that the number of *Diplostomulum* in fish may amount to 500 in both eyes. Nordmann (1832) quotes 400 as a maximum number in one eye of *S. erythrophthalmus*. The number of *D. spathaceum* in the eyes of fish varies from 1 to 20 at the delta of the Volga and in extreme cases it amounts to 176 and 180 there (Dubinin, 1952).

Table VIII

Diplostomulum spathaceum (Rudolphi, 1819)

(Invasion of older fishes in 1950 — 51)

Host	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
Esox lucius (L.)	63	2	3.0	1.0	0.03	2	1
Rutilus rutilus (L.)	50	35	70.0	30.8	21.5	1073	1 — 102
Scardinius erythrophthalmus (L.)	22	12	54.0	9.8	5.3	117	1 — 20
Aspius aspius (L.)	4	1	25.0	6.0	1.5	6	6
Gobio gobio (L.)	10	7	70.0	4.4	3.1	31	2 — 7
Alburnus alburnus (L.)	5	3	60.0	2.7	1.6	8	1 — 5
Blicca björkna (L.)	28	18	64.0	9.3	6.0	167	1 — 36
Abramis brama (L.)	49	41	83.5	33.0	27.6	1352	1 — 146
Rhodeus sericeus Bloch	18	9	50.0	7.8	3.9	71	4 — 15
Perca fluviatilis (L.)	58	18	31.0	4.2	1.3	76	1 — 15
Lucioperca lucioperca (L.)	8	1	12.5	6.0	0.75	6	6
Acerina cernua (L.)	23	4	17.4	1.3	0.22	5	1 — 2

The number of parasites in the eyes of older fish at Drużno varies from 1 to 10 and from 1 to 20 and amounts to 146 (in *A. brama*) and to 102 (in *R. rutilus*) in extreme cases. On the other hand, the percentage of invasion is very high in many species of *Cyprinidae* (Table VII).

Diplostomulum spathaceum sems to be more pathogenic than *Diplostomulum clavatum*. Although the effect of young wandering metacercariae is probably almost identical in both species, the effect of settled metacercariae seems to be more harmful in the case of *D. spathaceum*. In stronger invasions this parasite may cause the obfuscation of the lense and also exophthalmus, the protrusion and fracture of the cornea, and, indirectly, the death of fish.

It is noteworthy that especially *Salmonidae*, and first of all *Salmo salar* and *Salmo irideus* are susceptible to the effect of *D. spathaceum* (Schäperclaus, 1954; Lajman, 1949, and others). We did

not try to find out how young *Diplostomulum spathaceum* metacercariae wandered through the body of older fish. Szidat (1920) writes that they wander to the eye chiefly through the blood. Our observation of fry disprove these suggestions by Szidat. We invaded fry coming from the Konfederacka sand-bank on the Vistula with *Diplostomulum spathaceum* cercariae and found out that metacercariae of this parasite invade the youngest fry all over the surface of the body and then wander not through the blood but through all tissues and organs in their way to the eye, viz., through the muscles, brain, kidneys, liver, heart or spinal cord. They destroy or damage the blood vessels they meet along their way and often cause haemorrhages. We suppose that many, if not all, species wander in the same way in fry, as that is how young metacercariae generally behaved which came from an invasion in natural conditions at Drużno when we observed them investigating the youngest fry at the lake.

No diseases related to the presence of *Diplostomulum* were observed in fishes at Lake Drużno. It is true that a slight obfuscation of the lense seen only through the magnifying glass was recorded fairly frequently, but a distinct one seen with the unarmed eye was recorded only once, in *A. brama*.

The degree of invasion by *Diplostomulum spathaceum* is relatively low in the Drużno fry. The parasite may be found in the first category of growth (1—1.5 cm), but its number is small (1—2). It grows slowly in the next categories and amounts to no more than 6 to 8 in both eyes. Two cases of maximum invasion, 16 and 20 specimens in both eyes were observed each once in the growth category of 30 to 40 cm. On the other hand, the percentage of invasion in fry is fairly high; it proved to grow with age and reached 28% in specimens 5 cm in length in 1951—53.

As is known from literature (Wunder, 1926; Szidat, 1920) a longer and closer contact of fishes with *Limnaea stagnalis* heavily invaded by *Diplostomulum spathaceum* cercariae may result in loss of eyes and even mass casualties.

We observed a high degree of invasion in fry at low water in the Vistula in hollowings then cut from the Konfederacka sand-bank (partly dry at that time) near Płock.

Apart from the efect of *Diplostomulum spathaceum* we wish to add that completely blind fishes are sometimes met at Lake Drużno. Fishermen supplied us with two completely blind specimens of *A.*

brama in 1953. Both fishes were extremely emaciated and their eyes, and strictly speaking the cornea and the lense, were white and quite opaque. The chorioid and the retina were decayed. Microscopic examination showed no parasites in the body of the fish.

Ligula intestinalis L., 1758

Among tapeworms, only the plerocercoid *Ligula intestinalis* is of major economic importance at Lake Drużno. The pathogenic effect of this parasite causes castration on the one hand, and peritonitis, the destruction of the liver and a direct or indirect death of the host on the other. According to Plehn (1924) and Schäperclaus (1954) the presence of *Ligula* has an adverse effect on the rate of growth in invaded fishes, which was questioned by Zawisza (in litteris, 1954). The most extensive and exhaustive monographic description of ligulosis is by Willer (1912), who considers the pathogenic effect of *Ligula* to be purely mechanical. The Soviet writers have recently point out great changes in the morphotic composition of blood in sick fishes (quoted after Lajman, 1949). The changes caused in the pituitary gland by castration were described by Kerr (1942).

At Lake Drużno in 1950—51, 19% of *A. brama* and *B. björkna* and 3.7% of *R.rutilus* were invaded; the intensity of invasion varying usually from 1 to 2 and in extreme case of invasion by 23 specimens found in *B. björkna*. Besides, a very high invasion was observed in *Rhodeus sericeus* (72% of invasion) in 1950, in *B. björkna* fry 5 to 7 cm long (54% of invasion) in 1951, and in *A. alburnus* (32% of invasion) in 1953. It is noteworthy that ligulosis in *B. björkna* and *Rhodeus sericeus* was limited to a small part of the lake.

The invasion of *Cyprinidae* at the delta of the Volga was far higher than at Drużno and younger fish were more strongly invaded than older ones, which, for that matter, was observed as early as 1939 for *A. brama* of the Caspian Sea by Dogiel and Bychowski, and more recently for *A. brama* of Havel and several lakes in Holstein, Germany by Schäperclaus and Laskar (quoted from Schäperclaus, 1954). Dubinin (1952) explains the lower percentage of invasion in older fishes by a great number of young invaded specimens being eaten by birds. We can only add on the basis of our own observations that predatory fishes have a considerable share in eating fishes suffering from ligulosis.

At Lake Drużno, just as at the delta of the Volga, the younger generations proved to be most strongly invaded and *Ligula* invasion was observed already in *B. björkna* fry 5—7 cm in length.

Diseases of fry

Neascus scardinii (Schulman)

Syn.: *Neodiplostomulum scardinii* Schulman.

Neascus scardinii is one of the most common parasites of fry at Lake Drużno. Its cysts are small, slightly oval, thin-walled and transparent. They occur in the brains most frequently and more seldom in the eyes and appear in the youngest fry as early as the beginning of July, often with *Posthodiplostomulum brevicaudatum* cysts. 27% of fry were invaded by it in 1951—53 (Table XIII). This percentage varies from year to year and one age category to another (Table IX).

Table IX

Neascus scardinii (Schulman)
(Invasion of adult fishes and fry at Drużno in 1951)

Host & length of fry in mm	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
R. rutilus (L.)	23	2	4.3	11.5	1.0	23	2 — 21
Scardinius erythrophthalmus (L.)	5	3	60.0	4.3	2.6	13	2 — 8
0 — 15	35	9	25.7	3.1	0.8	28	1 — 11
15 — 20	87	45	51.7	4.0	2.1	184	1 — 13
20 — 30	140	52	30.0	5.0	1.8	261	1 — 18
30 — 40	64	8	12.5	2.6	0.3	21	1 — 8
40 — 50	25	0	0	0	0	0	0
over 50	4	0	0	0	0	0	0

It rises first in the youngest fry and falls in the older fry. The intensity of invasion in the eyes is far lower and usually varies from 1 to 2, less frequently from 2 to 4. Only on one occasion during the three years' investigation period 9 cysts were observed in one eye of a one-year *R. rutilus* 3 cm in length.

Occurring in so considerable a percentage of fry, *N. scardinii* may be found in older fishes, chiefly in *S. erythrophthalmus*, to which it

is specific. The percentage of fishes invaded by it varies. It was 60% in 1951, 85% in 1952 and 100% in 1953. It is as a rule a brain parasite in *S. erythrophthalmus*. It is far less frequent in the eyes. The intensity of invasion in the brain generally varies from 1 to 15, but sometimes surpasses the latter figure and shoots up to 100, 225 or 650. In the eyes, the intensity of invasion varies most frequently from 1 to 4 and amounts to 16 and 18 in one eye in extreme cases.

N. scardinii is not connected with Lake Drużno in any special manner. We used to find it in fry and *S. erythrophthalmus* also at Lake Łabędzie, which, like Drużno, is a bird reserve, and at Lake Kortowo, where there are relatively few birds.

We regard *N. scardinii* metacercariae as identical with *Neodiplostomulum scardinii* metacercariae, found by Schulman in the brain of *S. erythrophthalmus* in the Danube and the Western Dvina, USSR. Somewhat later than Schulman, Malewicka and Ginecinska also found it in the brain of *S. erythrophthalmus*, the former in Dnieper and the latter at the delta of the Volga (quoted from Dubinin, 1952).

Posthodiplostomulum brevicaudatum (Nordmann, 1832)

Syn.: *Neascus brevicaudatum* (Nordmann, 1832).

The cysts of the parasite, more elongated and larger than those of *N. scardinii*, while equally transparent and thin-walled, appear in one-year-old fry in the beginning of July. They settle almost exclusively in the eyes. In 1951—53, the *P. brevicaudatum* invasion of fry amounted to 10.9% (Table XIII). It rose, like in the case of *N. scardinii*, in the first category of growth, and then fell (Table X). The intensity of invasion most frequently varies from 1 to 2, less frequently from 2 to 4 in one eye. The parasite was only once found in the brain.

Among the older fishes we found *S. erythrophthalmus* to be almost the only one at Drużno to contain *P. brevicaudatum*, which was as specific to it as *N. scardinii* and in which it occurred not only in the eyes but also in the brain, yet its number was not large and it was always accompanied by *N. scardinii*. The percentage of *P. brevicaudatum* invasion in the brain of adult *S. erythrophthalmus* was relatively low, while the intensity of invasion in this organ of adult *S. erythrophthalmus* usually varied from 1 to 4 specimens, someti-

Table X

Posthodiplostomulum brevicaudatum (Nordmann, 1832)
(Invasion of adult fishes in 1950—51 and of *Cyprinidae* fry in 1951)

Host & length of fry in mm	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
Rutilus rutilus (L.)	50	3	6.0	2.7	0.16	8	2—3
Scardinius erythrophthalmus (L.)	22	3	13.7	2.7	0.36	8	2—3
Perca fluviatilis L.	58	1	1.7	3.0	0.051	3	3
1—15	35	3	8.5	2.5	0.2	7	1—4
15—20	87	8	9.2	2.7	0.3	22	1—4
20—30	140	8	5.7	1.7	0.1	14	1—4
30—40	64	5	7.8	1.4	0.1	7	1—3
40—50	25	1	4.0	1.0	0.04	1	1
over 50	4	0	0	0	0	0	0

mes being 8, 10 and 23. If the percentage of invasion was greater, the intensity of invasion in the eye was 1—4 and once only 18 (in 1953). Besides *S. erythrophthalmus* we found *P. brevicaudatum* at Drużno in *R. rutilus* (in 3 out of 50 fishes examined in 1950 and 1951) and in *P. fluviatilis* (in 1 out of 48 fishes examined in 1951—53).

P. brevicaudatum was found also in fry and older *S. erythrophthalmus* at Lake Łabędzie. Besides *S. erythrophthalmus*, one *E. lucius* was found to be invaded there (15 specimens of the parasite in one eye); 9 specimens of the parasite were found in *R. rutilus* at Lake Harsz and 3 in *Leucaspius delineatus* at Lake Gołdapiwo. We found *P. brevicaudatum* in 80% of *P. fluviatilis* examined at Lake Oświn.

Tetracotyle sp. 1

Large and almost immobile *Tetracotyle* sp. 1 metacercariae appeared to be coal-black when observe through the microscope, but when seen with the unarmed eye they were milk-white.

They occur in fry early in July. They lie freely in the fluid filling up the brain ventricles from July till the end of August. From then on they begin to encyst rapidly so that early in September they are mostly enclosed in thick, glassy and glass-hard sheath.

Fry was invaded in 20.5% by *Tetracotyle* sp. 1 in 1951—53. As in the case of the two species described above, this percentage rose in the first categories of age and fell in the later ones. The intensity of invasion at Drużno varied from 1 to 10 (Table XI, Diagram 4).

Table XI

Tetracotyle sp. 1

(Invasion of fry at Lake Drużno in 1951)

Length of fish in mm	Exam.	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
0 — 15	35	6	17.1	3.1	0.6	19	1 — 8
15 — 20	87	27	31.0	2.8	0.9	78	1 — 9
20 — 30	140	23	16.4	2.5	0.4	58	1 — 9
30 — 40	64	2	3.1	2.0	0.06	4	2
40 — 50	25	0	0	0	0	0	0
over 50	4	0	0	0	0	0	0

In full-grown fishes metacercariae of this parasite were not found. Beside Drużno we found *Tetracotyle* sp. 1 in one-year-old fry of *Cyprinidae* at Lake Łabędzie, and in fry at Lake Gołdapiwo in 1956 and at Lake Mamry Północne in 1957.

Tetracotyle sp. 2

Large, white *Tetracotyle* sp. 2 metacercariae settle only in the vitreous body of the eye. They occur in one-year-old fry early in July. They start to encyst more intensively in the second half of August. Their large, oval, hard and glass-like cysts resemble *Tetracotyle* sp. 1 in appearance.

The percentage of *Tetracotyle* sp. 2 invasion varied, as in the case of the three species described above, depending on the year and the category of growth (Table XIII). Fry was invaded by it in 8.5% in 1951—53.

The intensity of invasion in fry at Lake Drużno varied from 1 to 2. The cases of maximum invasion contained 3 to 4 specimens in one eye.

As regards adult fishes, *Tetracotyle* sp. 2 is a specific parasite of *P. fluviatilis*. It usually settles in the vitreous body of the eye. The intensity of invasion was higher than in fry varied from 1 to 5 on the average, in maximum cases amounting to 9 and 11 specimens in the eye.

Table XII

Tetracotyle sp. 2

(Invasion of adult fishes in 1950—51 and of *Cyprinidae* fry in 1951)

Length of fish in mm	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion
Perca fluviatilis L.	45	20	44.4	5.1	2.3	103	1 — 11
0 — 15	35	1	2.8	2.0	0.07	2	2
15 — 20	87	17	18.3	1.8	0.4	33	1 — 4
20 — 30	140	18	12.8	1.8	0.2	34	1 — 4
30 — 40	64	4	6.2	1.7	0.1	7	1 — 4
40 — 50	25	0	0	0	0	0	0
over 50	4	0	0	0	0	0	0

Beside Drużno, *Tetracotyle* sp. 2 was found in *Cyprinidae* fry at Lake Łabędzie, in adult *P. fluviatilis* at Lakes Łabędzie, Kortowo, Tajty and Harsz, in *P. fluviatilis* and in its fry 5 cm long on the Konfederacka sand-bank on the Vistula near Płock, where the intensity of invasion of the little *P. fluviatilis* 5 cm long varied from 2 to 40 in a fish and the percentage of invasion amounted to 90 in 1955.

Metacercariae living in the brain

In order to estimate the effect of metacercariae it is important to take into account the effect of young metacercariae, wandering in the body of the host as well as that of the already settled ones. This effect may be explained only by invading a fish in experimental conditions and checking the percentage of invasion in natural conditions at the same time. It seems however that the relatively low intensity of invasion of fry by brain and eye metacercariae which are at various stages of development at that, allows us to draw the conclusion that these metacercariae enter the fish in comparatively small numbers and not all at once but in groups in the natural conditions of Drużno. Consequently, it may not be presumed that the first stage, i. e. the entering of the cercariae and the wanderings of young metacercariae in the fish body, causes greater losses in the youngest generation at Drużno. Obviously, this does not exclude the possibility of single specimens or even whole schools of young fishes getting into the sphere of action of thousands of

Table XIII

Invasion of fry by *N. scardinii*, *P. brevicaudatum*, *Tetracotyle* sp. 1, *Tetracotyle* sp. 2, *D. spathaceum* and *D. clavatum* in 1951—53

Year	Examined	Invaded	% of invasion	Index of invasion	Average invasion	Total of parasites	Intensity of invasion	% of invasion in 1951 — 53
				Neascus scardinii				
1951	355	114	32.0	4.3	1.4	494	1 — 18	
1952	106	8	7.5	1.0	0.08	8	1 — 4	27.0
1953	126	34	27.0	4.7	1.3	158	1 — 16	
				Posthodiplostomulum brevicaudatum				
1951	355	25	7.0	2.0	0.1	51	1 — 4	
1952	106	13	12.2	2.0	0.2	26	1 — 4	10.7
1953	126	25	20.0	1.8	0.4	45	1 — 4	
				Tetracotyle sp. 1				
1951	355	58	16.4	2.6	0.4	159	1 — 10	
1952	106	33	31.3	3.0	0.9	98	1 — 8	20.5
1953	126	27	21.4	2.6	0.5	69	1 — 10	
				Tetracotyle sp. 2				
1951	355	40	11.2	1.9	0.2	76	1 — 4	
1952	106	3	2.8	1.0	0.03	3	1	8.4
1953	126	6	4.7	1.5	0.07	9	1 — 3	
				Diplostomulum spathaceum				
1951	355	70	19.7	2.6	0.5	183	1 — 8	
1952	106	29	27.4	1.7	0.4	49	1—4 (20)*	20.5
1953	126	21	17.0	3.1	0.5	66	1 — 7	
				Diplostomulum clavatum				
1951	355	30	8.2	5.2	0.4	156	1—18(20)*	
1952	106	3	2.7	2.7	0.07	8	1 — 4	6.5
1953	126	5	4.0	2.0	0.08	10	1 — 16	

* Figures in brackets denote numbers of parasites found only once in 1951—1953

cercariae just leaving snails or large accumulations of invaded snails, and, consequently, of more obnoxious and even fatal invasions.

N. scardinii, *P. brevicaudatum* and *Tetracotyle* sp. 1 metacercariae are the chief brain parasites of fry. When they reach the brain they settle in it in a characteristic way: most frequently in the second and third ventricles (Plate III, Phot. 2), less frequently and in smaller numbers in the aquaeduct of Sylvius (Plate III, Phot. 4), and least frequently over the corpora striata. The settling in the nervous tissue is very rare. If any parasites are found in it, they are usually young, still wandering stages. A similar distribution of *Tetracotyle petro-*

myzontis and *T. phoxini* in the ventricles was observed by Brown (1899), Metarè (1910) and Aschworth (1926). The presence of parasites in the brain ventricles obviously causes several changes. We observed changes in the brain caused by *Tetracotyle* sp. 1 in fry only, and also changes caused by *N. scardinii* and *P. brevicaudatum* in fry as well as adult forms. In uninvaded fry (Plate III, Phot. 1) the brain ventricles appear as narrow, hardly perceptible fissures. The changes in the brain caused by the presence of the parasite are quite distinct even at first sight. First of all, the ventricles are up to a hundred times larger and filled with fluid (Plate III, Phot. 2, 3 & 4) which stains pink with eosin and intense azure by the Mallory method; the already encysted specimens of *N. scardinii* may be found in the ventricles beside the young *Tetracotyle* still unencysted. The former may be distinguished by their very spacious thin-walled sheath (Plate III, Phot. 3 & 4).

The metacercariae filling up the brain ventricles exert a pressure on the surrounding tectum opticum, valvula cerebelli or cerebellum, or even the medulla oblongata. This pressure often causes changes in the structure of the brain and the arrangement of its parts. Thus, the valvula cerebelli, which fills up the inside of the third ventricle (Plate III, Phot. 1) in uninvaded specimens, is reduced to the size of a small processus (Plate III, Phot 2 & 4), is parallel to the cerebellum and directed upwards towards the tectum opticum in an invaded brain. Plate III, Phot. 4 shows the changes in the valvula cerebelli as well as those in the cerebellum, which is pushed upwards by the growing parasites. In addition to the dislocations in the brain, enlarged or even damaged blood vessels are often observed as well as haemorrhages, quite considerable at times.

The host reacts to the invasion of brain parasites chiefly by putting in action its defensive system. Soon after the invasion, the ependymal layer starts to grow exuberantly. Whole rows of cells leave it and get down inside the ventricles. They move towards the parasite, surround and isolate it (Fig. 3, 4; Plate III, Phot. 2; Plate IV, Phot. 1 & 2). Such growth of the ependyma was also observed by Brown and Matarè.

We did not succeed in establishing the character and origin of these wandering cells. The frequency of this phenomenon and the

occurrence of numerous mitoses in the ependymal layer (Fig. 4) seemed to suggest the neurogliac origin of the defensive elements. On the other hand, an accumulation of these elements in the nearest vicinity of the enlarged blood vessels (Fig. 3) also suggests their mesynchymal origin.

The application of Mallory's method did not serve the purpose. The wandering cells, accumulating in the ventricles and surrounding the body of the parasite with thick rings of many layers (Plate IV, Phot. 1 & 2) and often elongated and looking identical with fibroblasts never stained a distinct decided colour but dark violet,

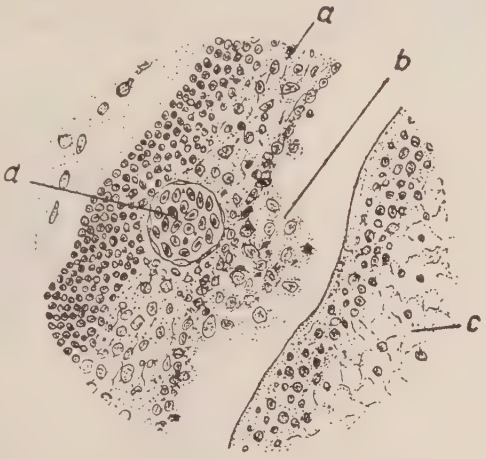

Fig. 3. Section through the brain of *Cyprinidae* fry invaded by *Tetracotyle* sp. 1. a — ependyme, b — cells wandering from ependyme toward the parasite; c — tissue of parasite; d — section through the blood vessel

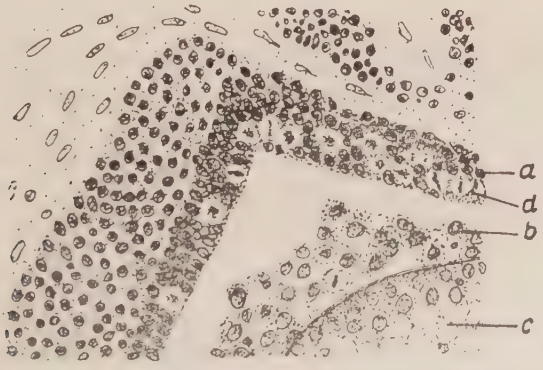

Fig. 4. Section through the brain of *Cyprinidae* fry invaded by *Tetracotyle* sp. 1. Explanations as in Fig. 3. d — mitosis

just as the brain tissues. Only the compact, transparent, stratified internal part of the sheath of *Tetracotyle* sp. 1 larvae stained intense

azure, a colour also characteristic of the connective tissue (Plate IV, Phot. 1).

We were not however able to establish the relation between the cells surrounding the body of the parasite and the internal sheath of the larva. The position suggests of course that the sheath originated from these cells, but the process of transition of free cells into a dead sheath is very difficult to observe in *Tetracotyle* sp. 1 .

Fig. 5. Section through the cyst of *N. scardinii*. a —brain tissue; b — cyst wall containing cells; c — parasite

Although we failed to establish the origin of the defensive elements, we think that the pressure and irritation caused by the parasite may stimulate the cells of the ependyma to grow exuberantly. According to Zawarzin (1946), who had given them the name of „endymologia" these cells are not quite differentiated and perform the function of the supportive and lining tissue in *Cyclostomata* and *Osteichthyes*. Such excessive growth of the ependyma cells in fish has already been observed by Brown and Matarè.

It would also be interesting to establish whether the fluid so profusely filling up the brain ventricles is a filtrate of the blood plasma which has passed through the walls of the enlarged vessels (a usual phenomenon concomitant to inflammations) or whether the secretory cells of the „margin" of the ependyma, the role of which in the formation of the cerebro-spinal fluid is already known. take a part

in its formation. The whole of the defensive action of the organism seems to consist essentially in isolating the parasite by forming a sheath around it with the help of the cells discussed above. Yet this sheath is formed in a different way in the case of *N. scardinii* and *P. brevicaudatum* than in that of *Tetracotyle*. *P. brevicaudatum* and *N. scardinii* are surrounded with a very thin layer of cells (Fig. 5) which finally transform into a thin sheath around the parasite (Fig. 6). The *Tetracotyle* parasites are surrounded with a thick ring,

Fig. 6. Section through the cyst of *N. scardinii*. a — brain tissue; b — cyst wall, indistinct intercellular boundaries; c — parasite

consisting of many layers (Plate IV, Phot. 1 & 2) which partly transforms into a thick, compact and hard sheath of the larva (Plate IV, Phot. 1). Beside the parasite, the thin-walled *N. scardinii* and *P. brevicaudatum* cysts contain a fluid which makes them properly elastic (Plate IV, Phot. 3). *Tetracotyle* sp. 1 cysts do not contain any fluid and they surround the parasite alone (Plate IV, Phot. 1). Further differences consist in that in the case of a heavy *P. brevicaudatum* and *N. scardinii* invasion the whole space of the ventricle in fry and older fish is filled with the parasite cysts closely adjoining each other (Plate IV, Phot. 7 & 8 and Plate III, Phot 3), while in the case of a heavy *Tetracotyle* sp. 1 invasion the compact and thick cysts cannot adjoin each other closely and the exuberantly growing ependyma cells enter, and finally fill in the gaps, between them. They remain in connection with both the outer layers of the sheath and the ependyma cells (Plate IV, Phot. 2 & Fig. 7). Numerous, spindle-formed fi-

brous cells, lying on the margin, and parallel to the lumen of the ventricles (Fig. 8) are observed in the latter in that period.

The strongest reaction to the presence of the parasite on the part of the host is observed in the period when the parasites are not yet encysted. It is a period of the growth and development of metacercariae. It seems that once encysted, the parasite has no greater effect on the organism of the host beside pressing against it.

Among older fishes, *N. scardinii* and *P. brevicaudatum* were found almost exclusively in *S. erythrophthalmus*. As specific parasites they seem less pathogenic for this species than for fry. A bigger size of the brain in older fish may also play a certain part here. Both species of metacercariae were found chiefly in the third ventricle. The ventricles were not so considerably enlarged and filled with the liquid as was the case with fry. The young forms of the parasite gather in the ependymal layer without reaching — in the cases we observed at least — the granular layer. They seem to stop only in the ependymal layer, close to the ventricle, in their wandering through the brain (Plate IV, Phot. 4). Where they settle, destruction or recession of the surrounding tissue may be observed, and a liquid accumulates which stains intense azure by the Mallory method and intense pink with eosin. In a certain time the parasite is surrounded with a very thin layer of the cells of the host (Fig. 5) and a sheath is formed (Fig. 6). The cysts are then pushed towards the ventricle, perhaps because of less resistance from it. As more of them are gathered a cavity is formed by the pressure. The ventricles are filled with a thick liquid in which single cells or their remnants may be distinguished. We used to find *N. scardinii* metacercariae also on the surface of the brain very frequently. The same applies to *Tetracotyle* sp. 1 as well.

Numerous hollowings, filled up by cysts, form in the ependymal layer and the valvula cerebelli under the pressure caused by the cysts. The cysts adjoin, or concresce with, each other, get sheathed together, and consequently transparent packets are formed consisting of more single cysts. Although, as was said above, numerous hollowings form in the ependymal layer and the valvula cerebelli under the pressure from them, we failed to observe a valvula turned upwards in the adult *S. erythrophthalmus* examined.

Despite the described changes in the brain of fry and also older forms of *S. erythrophthalmus* we did not succeed in establishing

certain cases of death. First we were of the opinion that so great deformities had to result in death, especially in younger fishes. (Only on closer examination of the distribution of metacercariae in the brain we realized why fishes may not die from the direct effect of the parasite). It follows from the experimental studies on the function of various parts of the brain in fishes, quoted by W u n d e r (1936), that only those die which got one of their vital centres damaged during the operation. The compensation capacity of the central nervous system in fishes is so great that even the specimens with their mesencephalon or cerebellum completely cut out survived for some time in an aquarium, ate and behaved normally. No wonder then that fry with the valvula cerebelli distorted and destroyed, the mesencephalon stretched to the utmost but not cut out and the cerebellum flattened but not removed should have been able to live in laboratory condition. We used to keep them for a few months without many casualties.

Fig. 7. Section through the part of a cyst of *Tetracotyle* sp. 1. a — ependyme; b — spindle-like cells wandering from ependyme; c — layered sheath of the parasite; d — parasite

Fig. 8. Section through the part of a cyst of *Tetracotyle* sp. 1. a — fibrous cells in the ependyme layer; b — layered sheath of the parasite; c — blood vessel

What may be observed in natural conditions is quite different. The invaded fry left by itself decreases in number slowly but continuously. As is shown in Table IX, X, XI and XIII referring to

the invasion of fry at Lake Drużno by *N. scardinii, P. brevicaudatum, Tetracotyle* sp. 1 and *Tetracotyle* sp. 2, the percentage of invasion rises in the first categories of growth and then falls to zero. We suppose that this sharp fall is somehow related to the changes observed in the tectum opticum, the distortion and atrophy of the valvula cerebelli and the distortion of the cerebellum. In aquarial conditions they usually do not cause the immediate death of the host, but they may have an adverse effect on the powers of association, supposed (Wunder, 1936) to reside in the mesencephalon, blunt the „quadruple reflex", a kinetic reaction to an imminent danger perceived by hearing or sight originating in the mesencephalon. Finally, they may, in connection of the atrophy of the valvula and the distortion of the cerebellum, unfavourably affect the efficiency of the movements, cause the failure of some of the impulses sent by the lateral line to reach their destination or weaken the control of the movements (Seep, 1949). Despite a great compensation power of the central nervous system in fishes the joint action of the above factors may in some measure weaken the vitality of fry and its power to determine the depth control, the movements control, avoid dangers and enemies. In this connection it may not die directly of invasion but be slowly eaten up by birds or predatory fishes and die of unfavourable conditions of the environment.

Such egress of invaded young generations from the biocoenosis seemingly incongruous with the „interest" of the parasite may even be advantageous to it if it turns out that its definitive host is a bird feeding chiefly on fry.

Metacercariae living in the eyes

In addition to *Diplostomulum spathaceum* and *Diplostomulum clavatum,* very common and found in the eyes, three more species, *N. scardinii, P. brevicaudatum,* and *Tetracotyle* sp. 2 are fairly often found at Lake Drużno, chiefly in fry. *N. scardinii* and *P. brevicaudatum* always settle next to the chorioid or the retina. Thus, they are met between the sclera and the chorioid or in the chorioid itself, between the chorioid and the retina or in the retina itself, usually on the side of the optic nerve. Their pathogenic effect depends among other things on their number, location and size, the last being enormous in relation to the size of the body of the tiny hosts. Fewer of them settle under the sclera (Fig. 9), lift up the chorioid and press

on the blood vessels, which causes the undernourishment of those parts of the eye to which less blood is coming and makes difficult or impossible the accommodation of the part lifted up. If they get into the retina or the chorioid, they destroy them. Fig. 10 shows

Fig. 9. Longitudinal section through the eye of the *Cyprinidae* fry (0 +) invaded by *Posthodiplostomulum* sp. a — parasites encysted under sclera

a *N. scardinii* cyst settled in the retina exerting a pressure, the pigmentary epithelium separating from the retina, and the layer of cones and rods next to the parasite undergoing a complete destruction. If many such cysts get into the eye of fry or adult fishes they become blind.

In addition to the above metacercariae *Tetracotyle* sp. 2 is another eye parasite which settles in the vitreous body only. In order to get there it must pierce the chorioid and the retina. While doing so it drills a wide canal in them. When it grows it fills up most of the vitreous body (Fig. 11). As we found at Lake Łabędzie, where there were far more *Tetracotyle* sp. 2 than at Lake Drużno, the number of parasites in one eye of fry 5 cm long may reach up to 20.

Due to technical difficulties we could establish changes caused by the fluke on the basis of only one series of preparations. A section of an eye invaded by *Tetracotyle* sp. 2 (Fig. 11) shows the destruction of parts of the capillary vessels and haemorrhages into the vitreous body. The comparison of Fig. 12 a and b (sections of retina and chorioid of uninvaded and invaded eye of fry) shows that the blood vessels of the chorioid become enlarged and the chorioid itself disintegrates. Numerous elongated spindle-formed cells appear in the fibrous layer of the eye, while they have not been found in the fibrous layer of an uninvaded eye. We failed to observe however whether and in what way they take part in the defensive action of the organism and in isolating the parasite.

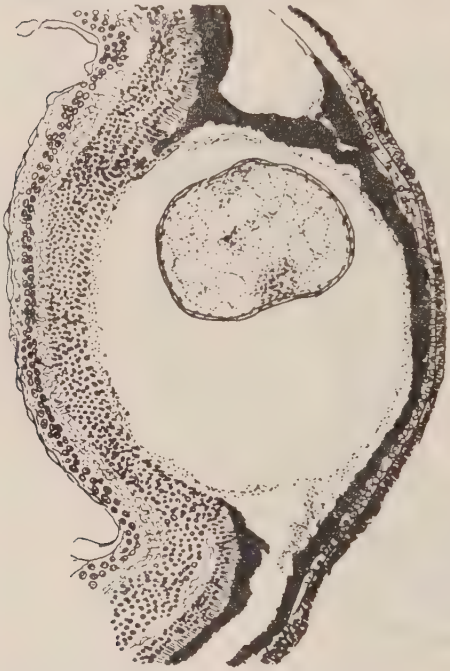

Fig. 10. Longitudiane section through the eye of the *Cyprinidae* fry (0 +) invaded by *Posthodiplostomulum* sp. encysted between chorioid and retina

The above described pathogenic changes in the brain and eyes are an indirect reason for the reduction of the number of more heavily invaded fry, but they do not explain the fall in the number of less heavily invaded fishes. Some light is thrown upon this problem by a comparison of the tables of invasion of older fishes and fry. It follows from them that in terms of the effect of metacercariae on fry there are two main groups. The first — Tables IX, X, XI and XIII — is represented mainly by *N. scardinii*, *P. brevicaudatum*, *Tetracotyle* sp. 1, and *Tetracotyle* sp. 2 and is characterized by a fall in invasion with the growth of fry. The other — Tables VI and VII — is represented by *Diplostomulum clavatum* and *D. spathaceum* and is marked by invasion growing with the age of the fish.

The parasites of the first group we find in older fishes, mainly or exclusively in *P. fluviatilis* and *S. erythrophthalmus*. *Tetracotyle*

sp. 1 are found nowhere else than fry. The parasites of the second group we find in 10 to 12 species. These relations may be explained by the fact that fry is probably less specific for cercariae invading fishes in the first period of its life. This again seems to be borne out by the fact that fry at Lake Drużno is heavily invaded by brain, eye and other metacercariae. They develop in fishes for some time and unfavourably affect their function as discussed above where changes were described brought about by brain parasites in fry. Consequently, in most cases a huge number of invaded fry die, usually for indirect reasons, as they fall victim to predatory animals or unfavourable conditions of their surroundings and only in few instances the fish organism succeeds in bringing the parasite to internal isolation, elimination and degeneration. Older fishes, which probably develop resistance to parasites non-specific to them, discontinue to be invaded by them for some reasons or other. The joint action of the damage done slowly but continuously to younger categories of growth and the fact that older categories do not become invaded sometimes accounts for a considerable fall in the percentage of invasion in the latter and in some cases for the appearance of an invasion threshold, i. e. of a certain break between the invasion of fry and of older fishes (Table IX, X, XI and XIII). It is very likely that the invasion by *N. scardinii* and *P. brevicaudatum* survived the *S. erythrophthalmus* fry.

Fig. 11. Longitudinal section through the eye of the *Cyprinidae* fry (0 +) invaded by *Tetracotyle* sp. 2. a — parasite; b — blood diffusion in retina

The process is quite different in the other group of parasites. The species which make it up show a wide specificity and they cause death only if a certain number of parasites is surpassed in various growth categories. While these casualties are not very high, as are e. g. those caused by *P. cuticola* in *A. brama* fry (D u b i n i n, 1952), it is difficult to asses them as they are compensated by the possibility of new successive invasions. In general, however, each category

of growth sustains a certain number of parasites without any losses, which brings about a steady increase of invasion with no invasion threshold appearing.

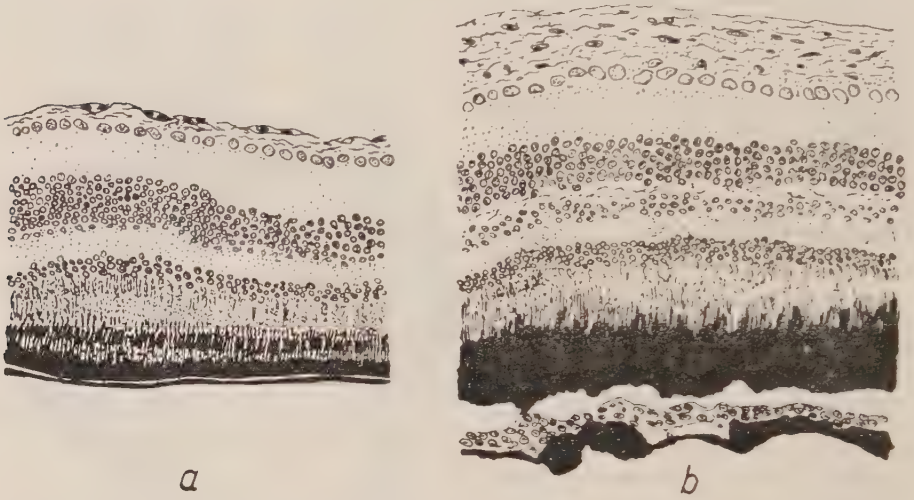

Fig. 12. Section through retina and chorioid of the *Cyprinidae* fry (0 +). a. Uninvaded eye; b. Eye invaded by *Tetracotyle* sp. 2

The discovery of *N. scardinii* not only in *S. erythrophthalmus* but also in *R. rutilus* and *P. fluviatilis*, and of *P. brevicaudatum* not only in *S. erythrophthalmus* but also in *R. rutilus*, *E. lucius* and *L. delineatus*, would be an argument in support of the opinion that these species gain new hosts.

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LITERATURE

1. Aschworth A. and Bennermann I. C. W. — On a *Tetracotyle (T. phoxini)* in the brain of the minnow. Trans. R. Soc. Edinb., LV (part I), 159—172, 1926.
2. Brown A. W. — On *Tetracotyle petromyzontis*, a parasite on the brain of *Ammocoetes*. Quart. Journ. Micr. Sc., 41, 489—497, 1889.
3. Daves D. J. — Pathological studies on the penetration of the cercariae of the Strigeid Trematode *Diplostomulum flexicaudum*. J. of Parasitology, 22, 329—337, 1936.
4. Dogiel W. A. — Parazitarnyje zabolewanija ryb w K.I.O. Moskwa-Leningrad, 1932.
5. Dogiel W., Bychowski B. — Parazity ryb Kaspijskogo Moria. Trudy ob izuczeniju Kaspijskogo Moria, 7, 1—149, 1939.
6. Dubinin W. B. — Zawisimost' rasprostranienija liczinok parazitarnych czerwiej w rybach delty Wołgi ot izmienienija miest koncientracji ptic. Zooł. Żurn., 28 (2), 131—136, 1939.
7. Dubinin W. B. — Fauna liczinok parazitarnych czerwiej delty Wołgi. Parazit. Sbornik Zooł. Inst. AN SSSR, XIV, 1952.
8. Dubinina M. N. — Nowyje dannyje kasajuszczyjesia morfołogii i biołogii predstawitielej roda *Ligula*. Zooł. Żurnał, XXIX (5), 417—426, 1950.
9. Dubois G. — Monographie des *Strigeida (Trematoda)*. Mem de la Soc. Neuchat., des Sc. Nat., 1938.
10. Halisch W. — Biologie von *Ergasilus minor* Halisch. Zeitschr. f. Parasitenkunde, 11, 284—330, 1939.
11. Heinemann E. — Wieder Fischsterben im Kurischen Haf. Fischerei Zeitung, 40, 1937.
12. Hubbs K. — The relativ effects of a parasite on a fish. J. of Parasitology, 4, 2, 76—84, 1929.
13. Kerr T. — The Pituitary in Normal and Parasitized Roach *(Leuciscus rutilus* Flem). Quart. J. of Micr. Sc., 89, 1948.
14. Kozicka J. — Parasites of fishes of Drużno Lake. Acta Parasit. Polon., VI, 23, 1958.
15. Kozicka J. — Pasożyty i choroby ryb jeziora Tajty. Roczniki CIR, 1953.
16. Lajman E. M. — Kurs bolezniej ryb. Moskwa, 1949.
17. Matarè F. — Über eine neue *Tetracotyle* im Hirn von *Phoxinus laevis* S. A. Zeitschr. f. Wiss. Zoologie, 94, 1—54, 1910.
18. Markiewicz A. P. — Parazitarnyje zabolewanija ryb okrestnostiej Leningrada. Moskwa-Leningrad, 1934.
19. Markiewicz A. P. — Parazity ryb priesnych wod Ukrainskoj SSR. Izd. Akad. Nauk. Kijew, 1951.
20. Neuhaus E. — Untersuchungen über die Lebensweise von *Ergasilus sieboldi* Nordmann. Zeitschr. f. Fischerei, 27, 341—398, 1929.
21. Nordmann A. — Mikrografische Beiträge zur Naturgeschichte der wirbellosen Tiere. I Heft. Berlin, 1832.
22. Plehn M. — Practicum der Fischkrankheiten. Stuttgart, 1924.
23. Schäperclaus W. — Fischkrankheiten. Braunschweig, 1941.

24. Schäperclaus W. — Fischkrankheiten. Berlin, 1954.
25. Seep E. K. — Istorja razwitija nierwnoj sistiemy pozwonocznych. Moskwa-Leningrad, 1949.
26. Szidat L. — Über ein Fischsterben im Kurischen Haf. Zeitschr. f. Fischerei, 25, 1927.
27. Szidat L. — Beiträge zur Entwicklung der Holostomiden. II. Zool. Anz., LXI, 11—12, 249—266, 1924.
28. Willer A. — Beiträge zur Kenntnis der Bandwurmseuche (Ligulosis) der Brachsen oder Bleie (*Abramis brama* L.). Zeitschr. f. Fischerei, XVI, I Heft, 1912.
29. Wunder W. — Mutmassliche Schädigung der Karpfenbrut durch Gabelschwanzcerkarien. Fischereizeitung, 29, 429—443, 1926.
30. Wunder W. — Physiologie der Süsswasserfische Mitteleuropas. Handb. d. Binnenfischerei Mitteleuropas. 1936.
31. Wiśniewski W. L. — Characterization of the parasitofauna of an eutrophic lake. Acta Parasit. Polon., VI, 1, 1958.
32. Zawisza J. — Gospodarcze metody walki z ligulozą. Roczniki CIR.

STRESZCZENIE

Celem niniejszej pracy było wykazanie, jakie schorzenia infekcyjne i inwazyjne występują u ryb jeziora Drużno.

Badania były prowadzone w czasie kilkumiesięcznego pobytu autorki nad jeziorem Drużno w latach 1950—53. Wykonano ogólnie 1388 sekcji ryb dojrzałych i młodych, spośród których jedynie 96 ryb było wolnych od pasożytów. Mimo dużej ekstensywności zarażenia większość pasożytów nie wywołała zmian patologicznych.

Zasadniczym mym zadaniem było wykrycie tych form pasożytów, które mogą wywoływać powstanie objawów chorobowych w warunkach jeziora Drużno.

Okazało się, że najbardziej ważnymi pod względem ekonomicznym są następujące gatunki ryb: szczupak (*Esox lucius*), płoć (*Rutilus rutilus*), wzdręga (*Scardinius erythrophthalmus*), lin (*Tinca tinca*), karaś (*Carassius carassius*), krąp (*Blicca björkna*) i okoń (*Perca fluviatilis*). W czasie badań stwierdziłam, że ryby dojrzałe i narybek stanowią pod względem patogenicznym dwie oddzielne grupy. Najbardziej chorobotwórcze dla narybku okazały się pasożyty, dla których ryby są żywicielami pośrednimi, specjalnie larwy przywr, związane w swym rozwoju z ptakami, a szczególnie te, które umiejscawiają się w oczach lub mózgu. Narybek był zarażony nimi w 40 — 45%; pasożyty te mogły eliminować pewną część najmłodszej generacji. Największe

znaczenie patogenne dla starszej generacji ryb jeziora Drużno miały choroby infekcyjne, a z chorób pasożytniczych — ergasiloza lina.

W niniejszej pracy wzięłam pod uwagę zarówno choroby infekcyjne, jak i inwazyjne.

W czasie badań znalazłam cztery gatunki metacerkarii, występujące w oczach i mózgu ryb, a szczególnie narybku. Opisałam je w innym miejscu (K o z i c k a, 1957). Są to: *Posthodiplostomulum brevicaudatum* (N o r d m a n n, 1832) D u b o i s, 1937, *Neascus scardinii* (S c h u l m a n n), *Tetracotyle* sp. 1 i *Tetracotyle* sp. 2. Pierwsze dwa gatunki, dotychczas nie stwierdzone w Polsce, występowały w oczach i mózgu: spośród dwóch gatunków *Tetracotyle*, prawdopodobnie również nie opisanych, *Tetracotyle* sp. 1 jest specyficzny wyłącznie dla mózgu, natomiast *Tetracotyle* sp. 2 pasożytuje w oczach. Wszystkie cztery gatunki występowały w dużej ilości i wywierały wyraźny wpływ chorobotwórczy na ryby. Były to najważniejsze formy pasożytnicze jeziora Drużno.

Obok powyższych godne uwagi są *Ergasilus sieboldi* N o r d m a n n, 1832 i *Rhipidocotyle illense* (Z i e g l e r, 1883) V e j n a r, 1936, szczególnie ich formy larwalne, oraz metacerkarie *Posthodiplostomulum cuticola* (N o r d m a n n, 1832) D u b o i s, 1937, *Diplostomum clavatum* (N o r d m a n n, 1832) F a u s t, 1919 i *Diplostomum spathaceum* (R u d o l p h i, 1819).

Spośród tasiemców jedynie *Ligula* jest godna uwagi, gdyż inne tasiemce występowały w stosunkowo małej ilości.

Spośród chorób infekcyjnych największe znaczenie miała plamica zakaźna szczupaków i okoni oraz pewna choroba infekcyjna leszczy, której nie mogłam zidentyfikować.

EXPLANATION OF PLATES

Plate I

Section through the gill of *Tinca tinca*. 1. *Eryasilus sieboldi* on the gills. 2. Pathological changes caused by *E. sieboldi*. 3. *E. sieboldi* on the gill of *T. tinca*

Plate II

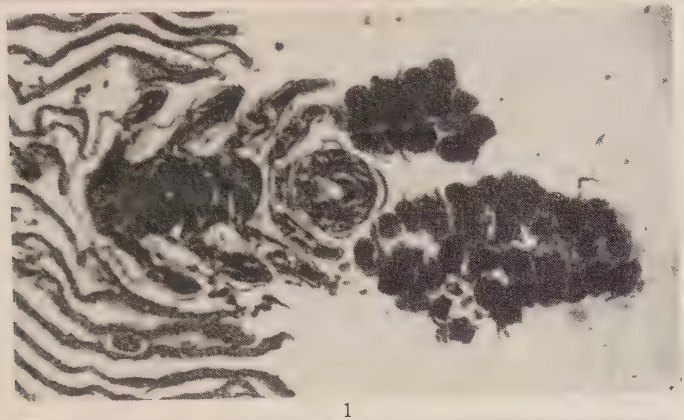
Section through the caudal fin of *Abramis brama*. 1. Cross section through the marginal ray containing cysts of *Rhipidocotyle illense*. 2. Section through the median ray; a diminution of number of cysts in relation to Fig. 1 is seen. 3. Longitudinal section through the marginal ray containing cysts of *R. illense*

Plate III

Longitudinal sections through the brain of one-year-old (0 +) fry of *Cyprinidae*. 1. Uninvaded brain; 2, 3, 4. Invaded brains. c — cerebellum; vc — valvula cerebelli; t. o. — tectum opticum; III — third ventricle; IV — fourth ventricle; T. sp. 1 — *Tetracotyle* sp. 1 not encysted; T. sp. 1 i — *Tetracotyle* sp. 1 encysted; N. sc. — *Neascus scardinii* encysted; s. k. — streaks of cells surrounding parasites; S — Aquaeductus Sylvii

Plate IV

1 and 2. *Tetracotyle* sp. 1 encysted in the third ventricle of brain of *Cyprinidae* fry (0 +). a — ependyme; b — cells wandering toward the parasite; c — many-layered ring surrounding the parasite; d — inner part of the sheath of parasite. 3 and 4. Section through the brain of *S. erythrophthalmus*, invaded by *P. brevicaudatum* (P. b.) and *N. scardinii* (N. sc.). Ep — ependyme layer; P — liquid in cysts



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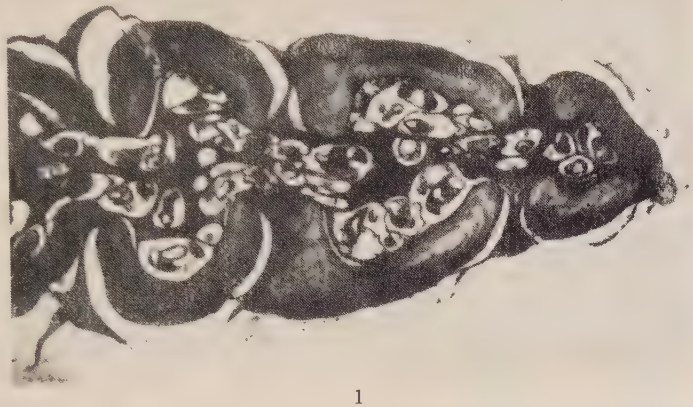

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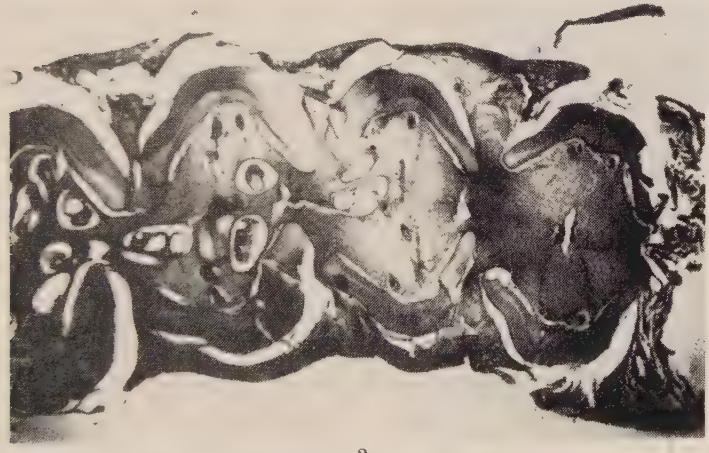

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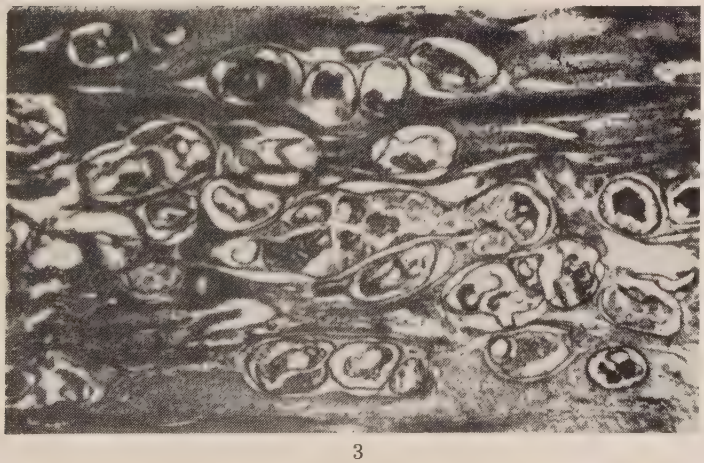

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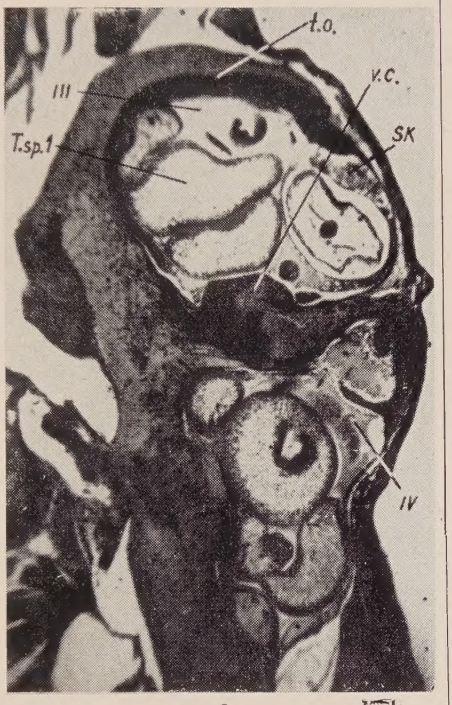

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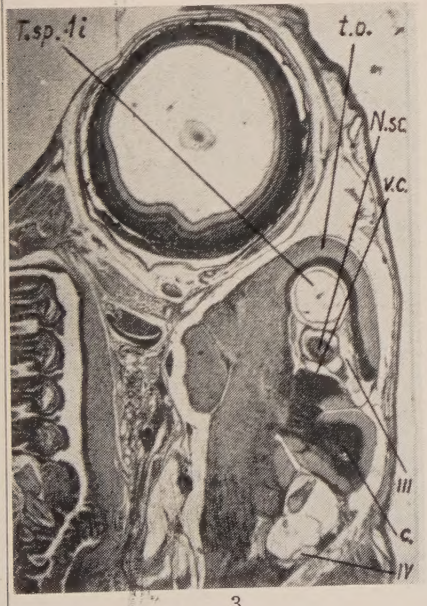

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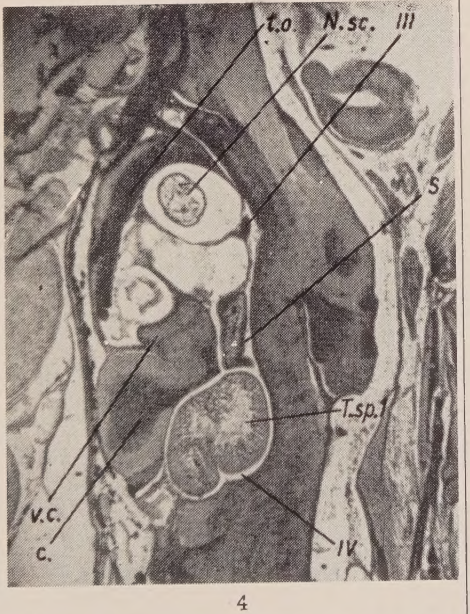

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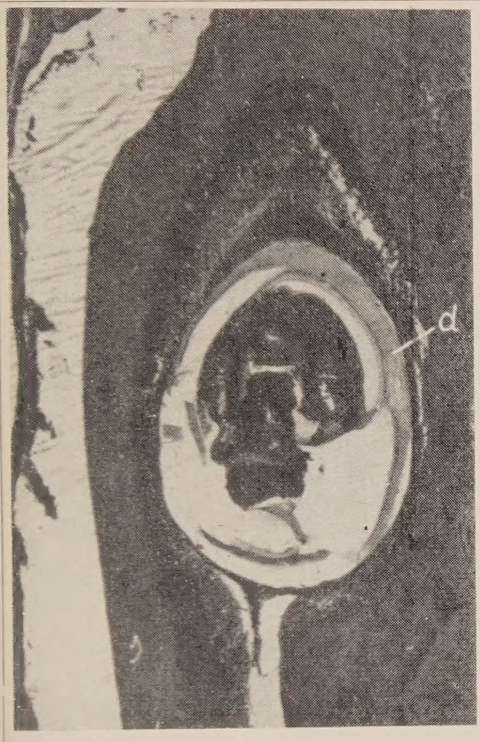

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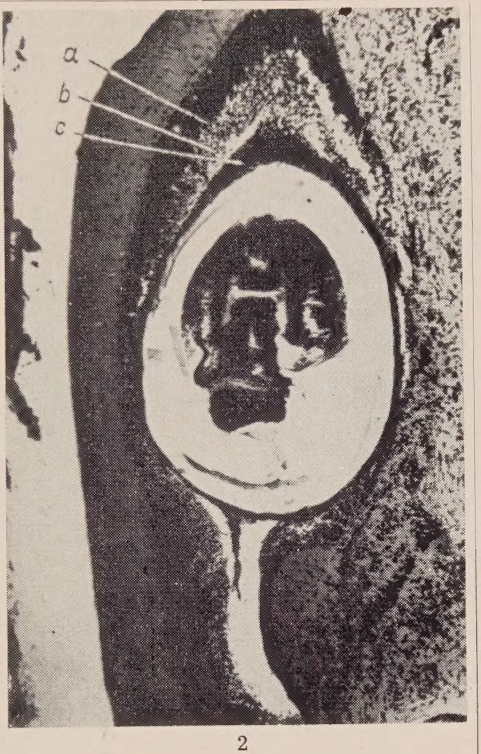

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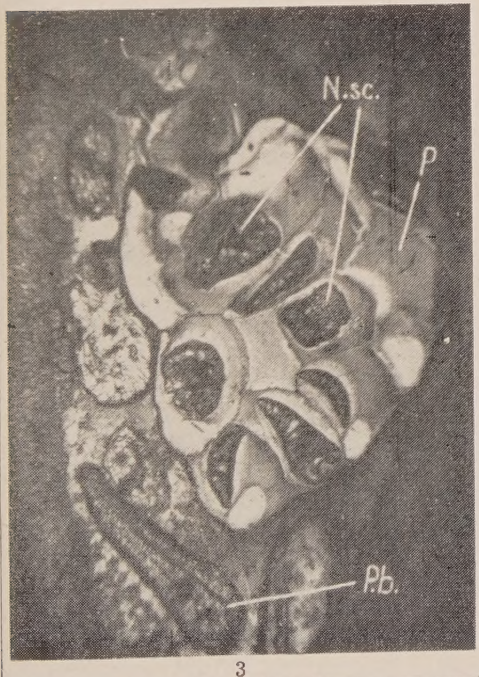

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